Entrance Examination Scheme for Non GATE candidates

ME(Chemical Engineering) & M.Tech.(Polymer Science & Technology)
Department of Chemical and Polymer Engineering

- The Question paper shall be of 100 marks.
- The exam shall be for duration of one and half hours [90 minutes].
- The question paper shall be divided in two parts –Part A & Part B

Part 'A' shall be of Engineering Mathematics. There will be 8 questions of 5 marks.

Part 'B' shall contain subject-related short questions. This part will be divided into following 9 sections. There will be 4 questions from each section. Each question will be of 10 marks.

i. Fluid Mechanics
ii. Heat Transfer
iii. Mass Transfer
iv. Thermodynamics
v. Materials Science & Technology
vi. Food & Bio-Chemical Engineering
vii. Physical and Inorganic Chemistry
viii. Organic Chemistry
ix. Polymer Science and Technology

ME (Chemical Engineering)

Candidate has to answer :

- any 4 question out of 8 questions in Part A (Marks 4 x 5 =20)
- any 8 questions of Part B. (Marks 8x10 = 80 marks)

M. Tech (Polymer Science and Technology)

Candidate has to answer any 10 questions from Part B. (Marks 10 x10 =100)

Part A

Mathematics Aptitude

Linear Algebra:
Algebra of matrices, inverse, rank, system of linear equations,symmetric, skew-symmetric and orthogonal matrices. Hermitian,skew-Hermitian and unitary matrices. eigenvalues and eigenvectors, diagonalisation of matrices.

Calculus:
Functions of single variable, limit, continuity and differentiability, Mean value theorems, Indeterminate forms and L'Hospital rule, Maxima and minima, Taylor's series, Newton’s method for finding roots of polynomials. Fundamental and mean value-theorems of integral calculus. Numerical integration by trapezoidal and Simpson’s rule. Evaluation of definite and improper integrals, Beta and Gamma functions, Functions of two variables, limit, continuity, partial derivatives, Euler's theorem for homogeneous functions, total derivatives, maxima and minima, Lagrange method of multipliers, double integrals and their applications, sequence and series, tests for convergence, power series, Fourier Series, Half range sine and cosine series.

Complex variables:
Analytic functions, Cauchy-Riemann equations, Line integral, Cauchy's integral theorem and integral formula Taylor’s and Laurent' series, Residue theorem and its applications.

Vector Calculus:
Gradient, divergence and curl, vector identities, directional derivatives, line, surface and volume integrals, Stokes, Gauss and Green's theorems and their applications.

Ordinary Differential Equation:
First order equation (linear and nonlinear), Second order linear differential equations with variable coefficients, Variation of Equations Probability parameters method, higher order linear differential equations with constant coefficients, Cauchy-Euler's equations, power series solutions, Legendre polynomials and Bessel's functions of the first kind and their properties. Numerical solutions of first order ordinary differential equations by Euler’s and Runge-Kutta methods.

Part B

I. Fluid Mechanics

Fluid Properties:
Relation between stress and strain rate for Newtonian fluids; Buoyancy, manometry, forces on submerged bodies.

Kinematics:
Eulerian and Lagrangian description of fluid motion, strain rate and vorticity; concept of local and convective accelerations, steady and unsteady flows

Control Volume Based Analysis:
Control volume analysis for mass, momentum and energy. Differential equations of mass and momentum (Euler equation), Bernoulli's equation and its applications, Concept of fluid rotation.

Potential flow:
Vorticity, Stream function and Velocity potential function; Elementary flow fields and principles of superposition, potential flow past a circular cylinder.

Dimensional analysis:
Concept of geometric, kinematic and dynamic similarity, Non-dimensional numbers and their usage.

Viscous Flows:
Navier-Stokes Equations; Exact Solutions; Couette Flow, Fully-developed pipe flow, Hydrodynamic lubrication, Basic ideas of Laminar and Turbulent flows, Prandtl-mixing length, Friction factor, Darcy-Weisbach relation, Simple pipe networks.

Boundary Layer:
Qualitative ideas of boundary layer, Boundary Layer Equation; Separation, Streamlined and bluff bodies, drag and lift forces.

Measurements:
Basic ideas of flow measurement using venturimeter, pitot-static tube and orifice plate.

II. Heat Transfer

Heat Transfer by Conduction:
Classification of different Modes; Concept of heat diffusion (conduction), Fourier's Law; Thermal Conductivity – constant and variable; Thermal Diffusivity; Steady State Conduction – Rectangular (Cartesian), Cylindrical and Spherical coordinates; Compound Resistance in Series; Critical thickness of insulation, One dimensional unsteady state heat conduction, Lumped system analysis, Slab – use of transient temperature chart.

Heat Transfer by Convection:
Concept of convection, General Heat Transfer Equation (Convection-Diffusion), Flow over a body – Hydrodynamic boundary layer, Drag coefficient, Drag force, Thermal boundary layer, Heat Transfer coefficient. Flow inside duct – Thermal boundary layer, Heat Transfer coefficient.
Heat Transfer in Turbulent Region: Dittus-Boelter Equation; Correction for temperature variation over pipe cross section; Physical Interpretation of different Dimensionless groups; Reynolds analogy, Colburn Analogy; Natural Convection; Correction of Laminar flow equation for Natural Convection.

Heat Transfer of Fluids with Phase Change:
Introduction; Dropwise and Film-Type Condensation; Coefficients for Film-Type Condensation: Nusselt Equation for Vertical and Horizontal Tubes; Condensation of Superheated Vapors; Heat Transfer to Boiling Liquids: Pool boiling of Saturated Liquid; Film Boiling.

Radiation Heat transfer:
Introduction; Monochromatic emissive power; Weins displacement law; Plank's law of radiation; Kirchoff,s Law; Emissivity of Solids; Absorption of Radiation; Lambert-Beer's law; Absorption by gases. Radiation between surfaces, Concept of View Factor.

Heat Exchange Equipments:
Typical Heat Exchange Equipment; Parallel Flow, Countercurrent Flow, and Cross Flow; General Design of Heat- Exchange Equipment; Different types of Heat Exchanger: Double Pipe Heat; Shell and Tube (1-1, 1-2, 2-4); Introduction to Plate Type; Condensers: Shell and Tube;
Evaporation:
Introduction; Liquid Characteristics; Types of Evaporator; Performance of tubular evaporator: Capacity, Steam economy; Boiling Point Elevation (Duhring Rule); Outside Heat Transfer Coefficients; Enthalpy Balance for a Single Effect Evaporator; Introduction to Multiple Effect Evaporator: Forward feed, Backward feed, Mixed feed, Parallel feed; Design concept of Multiple Effect Evaporator.

III. Mass Transfer

Fundamentals of Mass Transfer:
Principles of molecular diffusion and diffusion between phases, Fick's Law, Diffusivity, Equation of continuity, Diffusion in solids. A definition of Mass transfer coefficient, other definitions of mass transfer coefficient, correlation of mass transfer coefficients, Theories of Mass Transfer, mass transfer across interfaces, Analogy between momentum, heat and mass transfer, Concept of stage wise processes.
Absorption:
Introduction, The mechanism of absorption, Absorption equipment, Diameter and height calculations for packed columns, Kremser equation, H. E. T. P. , H. T. U. , and N. T. U. concepts, Packed tower design, height of column based on conditions in the gas film, height of column based on conditions in the liquid film, height of column based on overall coefficients, plate type towers, number of plates by use of absorption factor.
Distillation:
Introduction, Vapor -liquid equilibria, Relative volatility, Ideal and non -ideal solutions, Batch, differential and equilibrium distillation, Enthalpy concentration diagram, Rectification of binary systems, Design of rectification column, calculation of number of plates in a distillation column by McCabe-Thiele method, importance of reflux ratio, calculation of number of plates by Ponchon and Savarit method, Azeotropic & Extractive Distillations, Introduction to multicomponent distillation.
Adsorption:
Introduction, nature of adsorbents, batch adsorption, Adsorption isotherms, Adsorption equipment, breakthrough curves, design of fixed bed adsorption column.

Humidification and Dehumidification Processes:
Humidification and dehumidification operations, Characteristics of saturated and unsaturated vapor gas mixtures, Dry and wet bulb thermometry, Psychometric chart, Adiabatic saturation curves, Gas liquid contact, Design of humidifiers, Dehumidification operation, Principle and design of cooling towers (Natural draft, forced draft and induced draft cooling towers).

Liquid-Liquid Extraction & Leaching:
Introduction to Extraction, Liquid- liquid equilibria, Triangular diagram, Selectivity and choice of solvents, Stage wise contact, co-current & countercurrent extractor, Stage type extractors and differential extractors, Determination of number of equilibrium stages by graphical method for multistage extraction, Extraction efficiency. Introduction to leaching, general principle, factors affecting the rate of extraction, Liquid -solid equilibria, calculation of number of stages, batch processes, countercurrent washing, stage calculation methods.

Drying & Crystallization:
Introduction to drying, Rate of drying, Batch drying mechanism, the mechanism of moisture movement during drying, classification and selection of dryer. Introduction to crystallization, Theory of Crystallization, Formation and growth of crystals, crystal yield, Rate of crystallization.

Membrane & Separation Processes:
Introduction to advance separation processes, classification of membrane processes, Dialysis, Ultra filtration, Reverse Osmosis, reverse osmosis in water treatment plant, Electro dialysis, membrane fouling, liquid membrane.

IV. Thermodynamics

Basic Concepts:
Continuum, macroscopic approach, thermodynamic system (closed and open or control volume); thermodynamic properties and equilibrium; state of a system, state diagram, path and process; different modes of work; Zeroth law of thermodynamics; concept of temperature; heat.

First Law of Thermodynamics:
Energy, enthalpy, specific heats, first law applied to closed systems and open systems (control volumes), steady and unsteady flow analysis.

Second Law of Thermodynamics:
Kelvin-Planck and Clausius statements, reversible and irreversible processes, Carnot theorems, thermodynamic temperature scale, Clausius inequality and concept of entropy, principle of increase of entropy, entropy balance for closed and open systems, exergy (availability) and irreversibility, non-flow and flow exergy.

Properties of Pure Substances:
Thermodynamic properties of pure substances in solid, liquid and vapor phases, P-V-T behaviour of simple compressible substances, phase rule, thermodynamic property tables and charts, ideal and real gases, equations of state, compressibility chart.

Thermodynamic Relations:
T-ds relations, Maxwell equations, Joule-Thomson coefficient, coefficient of volume expansion, adiabatic and isothermal compressibilities, Clapeyron equation.

Thermodynamic cycles:
Carnot vapour power cycle; simple Rankine cycle, reheat and regenerative Rankine cycle; Air

standard cycles: Otto cycle, Diesel cycle, simple Brayton cycle, Brayton cycle with regeneration, reheat and intercooling; vapour-compression refrigeration cycle.

Ideal Gas Mixtures:

Dalton's and Amagat's laws, calculations of properties (internal energy, enthalpy, entropy), air water vapour mixtures and simple thermodynamic processes involving them.

V. MATERIALS SCIENCE & TECHNOLOGY

Structure:

Atomic structure and bonding in materials. Crystal structure of materials, crystal systems, unit cells and space lattices, miller indices of planes and directions, packing geometry in metallic, ionic and covalent solids. Concept of amorphous, single and polycrystalline structures and their effect on properties of materials. Imperfections in crystalline solids and their role in influencing various properties.

Diffusion: Fick's laws and application of diffusion.

Metals, Alloys and Ceramics:

Solid solutions, solubility limit, phase rule, binary phase diagrams, intermediate phases, intermetallic compounds, iron-iron carbide phase diagram, heat treatment of steels, cold, hot working of metals, recovery, recrystallization and grain growth. Microstrcture, properties and applications of ferrous and non-ferrous alloys. Structure, properties, processing and applications of ceramics.

Materials Properties:

Stress-strain diagrams of metallic, ceramic and polymeric materials, modulus of elasticity, yield strength, tensile strength, toughness, elongation, plastic deformation, viscoelasticity, hardness, impact strength, creep, fatigue, ductile and brittle fracture.Heat capacity, thermal conductivity, thermal expansion of materials. Concept of energy band diagram for materials - conductors, semiconductors and insulators, intrinsic and extrinsic semiconductors, dielectric properties. Origin of magnetism in metallic and ceramic materials, paramagnetism, diamagnetism, antiferro magnetism, ferromagnetism, ferrimagnetism, magnetic hysterisis, corrosion.

Structure and Properties of polymers: Monomers, functionality, degree of polymerizations, classification of polymers, glass transition, melting transition, criteria for rubberiness, Principle of polymerization, block and graft copolymers, techniques for copolymerization-bulk, solution, suspension, emulsion. Solubility and swelling, concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, polymer crystallinity,

Instrumental Analysis: IR, XRD, thermal (DSC, DMTA, TGA), microscopic (optical , SEM, TEM, AFM) techniques.

VI Food & Bio-Chemical Engineering

Biomolecules

Carbohydrate, Protein, Fat and amino acids. Nucleic acids. Major metabolic pathways.

Basic Microbiology

Structure of micro-organism, Microbial metabolism. Selective and Differential media. Enrichment culture Technique. Quantification of cells. Cell culture techniques. Different microbial products: Enzymes, antibiotics, vitamins and alcohol. Overview of Recombinant Technology.

Food Processing and Technology

Unit operation in food engineering, Preservation of food, Dehydration, Freezing, Evaporation, Refrigeration. Heat transfer in food processing. Membrane separation. Fermentation: Alcoholic beverages Food microbiology: Microbial contamination of food and food products. Microbial examination of food.

Bioprocess Technology

Kinetics of cell growth and product formation. Yield concept, Enzyme kinetics. Media and air sterilization. Aeration and agitation in bioreactor. Operating modes of bioreactor. Scale and scale down operation. Control of bioreactor. Instrument and control of bioprocess

Bioseparation

Product recovery: Filtration, Centrifugation, coagulation, Flocculation, Cell disruption techniques. Separation of soluble products: Extraction, adsorption, precipitation, ultrafiltration, chromatography, electrophoresis, electrodialysis. Aqueous two phase extraction and reverse micellar extraction. Supercritical fluid extraction Crystallisation and drying

Biological waste management

Physical, chemical and biological characteristic of waste water. Determination of BOD and COD. Primary and secondary treatment processes. Anaerobic digestion. Solid waste management.

VI . Physical and Inorganic Chemistry

[1] Basic principles and techniques of Quantum chemistry; postulates of quantum mechanics and Schrodinger equation, particle in one dimension, two dimension and three dimension box, degeneracy, Harmonic oscillator, rigid rotator and Hydrogen atom, angular momentum, shape of orbitals, spin-orbit coupling.

[2] Chemical Kinetics: Rates of chemical reactions, Arrhenius equation, theory of reaction rates: collision and transition state theory, elementary, consecutive, and parallel reaction: steady state approximation, concept of catalyst.

[3] Chemistry of main group elements: General characteristics, synthesis, structure and properties of their halides and oxides, polymorphism of carbon, phosphorous and sulphur. Synthesis, structure and properties of boranes, carboranes, borazines, phosphazenes, silicones. Interhalogens and noble gas compounds.

[4] Transition elements and coordination compounds: general characteristic of d and f block elements, coordination chemistry: structure, isomerism, bonding theories (VBT, CFT and LFT),

reaction mechanism (substitution and electron transfer reaction), electronic spectra, magnetic properties, spectral and magnetic properties of lanthanides and actinides complexes.

VII Organic chemistry

[1] Stereochemistry and Aromaticity: Chirality of organic molecules with or without chiral centres, configuration, Asymmetric synthesis, enantio and diastereoselective synthesis, stereoselective and stereospecific synthesis, Conformational analysis of cyclic and acyclic compounds, geometrical isomerism, Aromaticity; concept of aromaticity and Huckel rule in annulenes, fullerenes.

[2]Reaction Mechanism and pericylic reactions: Name reactions; Favorski reaction, Michael addition, Ene reaction, Barton reaction, Shapiro reaction, Baeyer-Villiger reaction, Chichibabin reaction, reagents in organic synthesis; DDQ, LDA, selenium dioxide, metal hydride, Pericyclic reaction : Electrocyclic, cycloaddition and sigmatropic reaction, Orbital correlation, FMO and PMO treatments, Cope and Claisen rearrangements.

[3]Spectroscopy and Biomolecules: Principles and applications of UV-visible, IR, NMR and Mass spectroscopy in the structure elucidation of organic compounds, Biomolecules; structure and function of biopolymers such as carbohydrates, protein, nucleic acid, steroids, terpenoids and alkaloids.

IX. Polymer Science and Technology

Chemistry of high polymers: Monomers, functionality, degree of polymerizations, classification of polymers, glass transition, melting transition, criteria for rubberiness, Principle of polymerization, addition and condensation polymerization; their kinetics, chain transfer, inhibition and retardation, control of molecular weight, branching effects of addition/chain growth polymerization, metallocene polymers and other newer techniques of polymerization, copolymerization, monomer reactivity ratios and its significance, kinetics, different copolymers, random, alternating, azeotropic copolymerization, block and graft copolymers, techniques for copolymerization-bulk, solution, suspension, emulsion.

Synthesis and properties: Commodity and general purpose thermoplastics: PE, PP, PS, PVC, Polyesters, Acrylic, PU polymers. Engineering Plastics: Nylon, PC, PBT, PSU, PPO, ABS, Fluoropolymers Thermosetting polymers: PF, MF, UF, Epoxy, Unsaturated polyester, Alkyds. Natural and synthetic rubbers: Recovery of NR hydrocarbon from latex, SBR, Nitrile, CR, CSM, EPDM, IIR, BR, Silicone, TPE. Functional polymers: Photo responsive polymers, Ion conducting polymers, Piezoelectric polymers, Inorganic polymers.

Polymer blends and composites: Difference between blends and composites, their significance, choice of polymers for blending, blend miscibility-miscible and immiscible blends, thermodynamics, phase morphology, polymer alloys, polymer eutectics, plastic-plastic, rubber-plastic and rubber-rubber blends, Polymer composite systems: Types of composites, reinforced thermoplastic, thermoset, elastomer - resins FRP, particulate, long and short fibre reinforced composites.

Polymer Technology: Polymer compounding-need and significance, Additives for Plastics: Definition, classification, mechanism of action, method of incorporation of: fillers, plasticizer, stabilizer, (antioxidants/ozonants) Colorants, cross linking agents, blowing agents, antistatic agents, coupling agents, flame retardants, antiblock agents,

Polymer processing: Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer.

Polymer testing: Mechanical-static and dynamic tensile, flexural, compressive, abrasion, endurance, fatigue, hardness, tear, resilience, impact, toughness. Conductivity-thermal and electrical, dielectric constant, dissipation factor, power factor, electric resistance, surface resistivity, volume resistivity, swelling, ageing resistance, environmental stress cracking resistance. Optical properties (gloss, clarity), Chemical properties (solubility, flammability, LOI, Vicat softening point & HDT, permeability, ageing & weathering, ESC, adhesion) flow properties (MFI, viscosity).